# PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

## An Acoustic Diaphragm.

I, ERNST OSCAR PERSSON, a Swedish subject, of Brunny, Nyhamnsläge, Sweden, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The acoustic diaphragms at present employed in apparatus for sending, receiving or recording sound, such as telephone receivers, loud-speakers, horns, microphones, phonographs etc. . . are generally formed of a single sheet of steel plate cardboard, mica, etc. . . . , having a uniform thickness, stiffness and elasticity at all points.

These diaphragms possess the disadvantage that they cannot reproduce sounds of different frequencies at the same time without distortion unless the impulses acting on the diaphragm are very weak, as is the case for example in a telephone receiver connected to the output terminals of a crystal radio receiver, and that they have a natural tone that deforms the reproduction.

Most of the inventors who have carried out research work on this subject have tried to overcome these disadvantages by constructing diaphragms of concentric cone frusta of different periods of oscillation or built up of separate pieces of different periods of oscillation. These searchers have thus empirically expressed principles such as: the mass per unit of surface must increase from the centre to the edge, or the stiffness must decrease in the same direction, or the ratio

$$\frac{\text{elasticity}}{\text{mass per unit of surface}}$$

must decrease from the centre to the edge and finally the mass and the stiffness must vary by degrees from zone to zone. Diaphragms have been conceived in which the thickness of the material of which they are made increases from the centre to the edge or from the edge to the centre, or in which the thickness varies round concentric lines. Others in which the diaphragm is attached to a resonance screen, or attached to a second diaphragm having a form of a cone frustum and which is made of a material of which the ratio

$$\frac{\text{elasticity}}{\text{mass per unit of surface}}$$

is less than for the conical diaphragm to which it is attached.

It has also been proposed to load a diaphragm with tapered lumped loading, the masses of loading being equally distributed over the surface of the diaphragm so that the distances between the masses are the same in both directions, and the masses in successive circles from the centre increase in magnitude outwardly.

The object of the present invention is to provide acoustic diaphragms for apparatus for sending, receiving or recording sounds and possessing the property of being capable of following oscillations of different frequencies, thus permitting a complex sound record such as an orchestral piece to be reproduced accurately.

The invention consists in an acoustic diaphragm particularly adapted for use in all apparatus for sending, receiving or recording sound such as telephone receivers, loud speakers, horns, microphones, phonographs and the like, characterised by the feature that the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

diminishes continuously and uniformly radially from the centre to the edge of the diaphragm.

The invention is based on the following considerations:

If a ring $b$, made of lead for example, is cemented on a vibrating plate $a$ (Figure 1) clamped in the usual manner at its periphery $a^1$, $a^2$, the inertia and consequently the period of the plate $a$ are increased while at the same time a circular zone of diameter $d$ is defined on this diaphragm within the ring $b$ which possesses a certain period of oscillation.

The diaphragm thus obtained will act as if there were two different diaphragms, one formed by the plate $a$ with the ring $b$, and the other by the circular zone of diameter $d$.

If the sounds to be reproduced or recorded have a frequency approaching that of the part $d$ it will be this part which enters into oscillation while the ring $b$ will form a kind of fixed boundary

[Price 1/-]

for the periphery of the part $d$; if the sounds have a frequency approaching that of the entire diaphragm taking into account the presence of the ring $b$, then the whole diaphragm will enter into oscillation.

If, instead of a single ring $b$, a plurality of concentric rings of the same type are arranged on the plate $a$, a diaphragm will be obtained as will be understood, which is capable of reproducing a greater number of frequencies.

The various experiments which the applicant has made in this direction have enabled him to obtain acoustic diaphragms which respond equally to all sound frequencies and in which a natural resonance period which is so detrimental to faithful reproduction, is suppressed.

The essential feature of these diaphragms consists in a construction such that the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

is uniformly decreased from the centre to the edge so that the smaller the value of said ratio as measured anywhere on a concentric line, the greater the diameter of the concentric line. The stiffness is defined as the resistance of the material against bending, at the concentric line in question as measured on a test piece. The above mentioned essential feature may be obtained for example by using two materials, one having practically no stiffness whereas it has a mass sufficiently great and one having practically no mass whereas it has a stiffness sufficiently great, the two materials being joined together axially so as to form a single sheet the thickness of the former increasing from the centre to the periphery while the stiffness of the latter diminishes in the same direction for example by decreasing uniformly its thickness from the centre to the edge or by using doped fabric and gradually diluting the impregnating material from the centre to the periphery during the impregnating process.

Various embodiments of these acoustic diaphragms will now be described by way of example with reference to the accompanying drawing.

The diaphragm shown in Figure 2 is formed by a support $a$ of uniform thickness made of a material having as high a stiffness as possible, such as iron, steel, hardened celluloid or other material, and a lining $c$ made of sufficently heavy material of small stiffness, such as rubber, and the thickness of which increases gradually from the centre towards the edges (in the drawing the thickness of the support has been slightly exaggerated).

In this diaphragm the stiffness is unchanged but the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

is diminished because of the increasing thickness of the rubber lining which increases uniformly the mass per unity of surface from the centre to the edge.

The presence of the layer of rubber also produces an appreciable damping of the natural oscillations of the support. This diaphragm is particularly suitable for microphones, phonographs, etc. . .

In the modification shown in Figure 3, the thickness of the support $a$ decreases from the centre to the periphery, and the lining $c$ has a section similar to that shown in Figure 2. This plate is suitable for loud-speakers, telephone receivers, etc. . . The support a may be formed for example of soft drawn, non magnetic iron.

The acoustic diaphragm shown in Figure 4 is of conical shape and is particularly suitable for motor horns. It consists of a support $e$ made of hardened celluloid, for example, of conical shape and uniform thickness, and a rubber lining $f$ the thickness of which increases from the apex to the base of the cone. Preferably the taper of the support increases from the apex to the base, so that this support has the general shape of a curved surface.

Naturally, the same modification shown in Figures 2 and 3 may be provided for Figure 4 and the thickness of the support $e$ may diminish from the apex to the base or else the reduction of the stiffness from the centre to the edge of this support may be obtained by processes such as graduated tempering, compression, impregnation or chroming, that is to say by processes in which the tempering, compression, impregnation or chroming effect varies progressively from the apex to the base or from the centre to the periphery.

The graduated hardening may be obtained for example by heating the disc at different temperatures from the centre to the periphery and subsequently immersing it in the hardening bath.

Finally, instead of being formed by a continuous conical or curved surface, the support shown in Figure 4 may also be formed by a series of elementary conical surfaces having a taper increasing from the centre to the outer edge of the support (Figure 4a).

A variation of this form of diaphragm is shown in Figs. 5 and 6. The elementary conical surfaces are here joined in such a way that the points of the cones or frusta are turned alternatively in opposite directions and have increasing height from the centre to the edge of the

diaphragm so that the circles $g^1$, $g^3$, $g^5$ on one side and $g^4$ and $g^2$ on the other, representing the bases of the elements will be situated on the two conical surfaces $h^1$ and $h^2$ which approach each other towards the centre of the diaphragm. Further, the taper of each successive frustum increases from the centre towards the periphery of the membrane. In order to soften the transition from one frustum to an adjacent one each frustum may comprise a complementary curvature as already stated above with respect to Fig. 4. The support is provided with a lining of rubber the thickness of which increases from the centre of the diaphragm to its edge as already described for the above mentioned forms of diaphragms and the frusta may be made separately and joined together or made in one piece.

It goes without saying moreover that modifications may be made in the modes of construction which have been described simply by way of example, without on that account departing from the scope of the invention. In particular the material indicated by way of example may be replaced by any other suitable materials in the construction of sound recording, receiving and reproducing apparatus. The embodiments described are moreover not the only possible embodiments of the invention.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An acoustic diaphragm particularly adapted for use in all apparatus for sending, receiving or recording sound such as telephone receivers, loud speakers, horns, microphones, phonographs and the like characterised by the feature that the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

diminishes continuously and uniformly radially from the centre to the edge of the diaphragm.

2. An acoustic diaphragm according to claim 1 composed of two materials superimposed one on the other and glued or otherwise adherently held together, the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

being at all points greater for one of the materials than for the other, characterised by the feature that the thickness of the material of which the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

is the smaller increases uniformly radially from the centre to the edge of the diaphragm, this material being for instance, rubber and the other material being steel, celluloid, mica, doped fabric and the like.

3. An acoustic diaphragm according to claim 2, characterised by the feature that the stiffness of the material, of which the ratio

$$\frac{\text{stiffness}}{\text{mass per unit of surface}}$$

is the greater, diminishes uniformly radially from the centre either by uniformly diminishing its thickness, or by a process of gradual impregnation, the material being for instance gauze or other light fabric impregnated with gelatine, the degree of dilution of the gelatine bath being progressively changed during the impregnation.

4. An acoustic diaphragm according to claims 1, 2 and 3 of conical shape characterized by the feature that the taper of the cone increases from the centre to the periphery either uniformly or by means of two or more frusta of which the taper and height increases from the centre to the periphery of the diaphragm and which may be turned with their smaller bases in the same or in opposite axial directions.

5. The improved acoustic diaphragm particularly adapted for use in apparatus for sending, receiving or recording sound, substantially as described and as illustrated in the accompanying drawing.

Dated this 19th day of December, 1930.

MARKS & CLERK.

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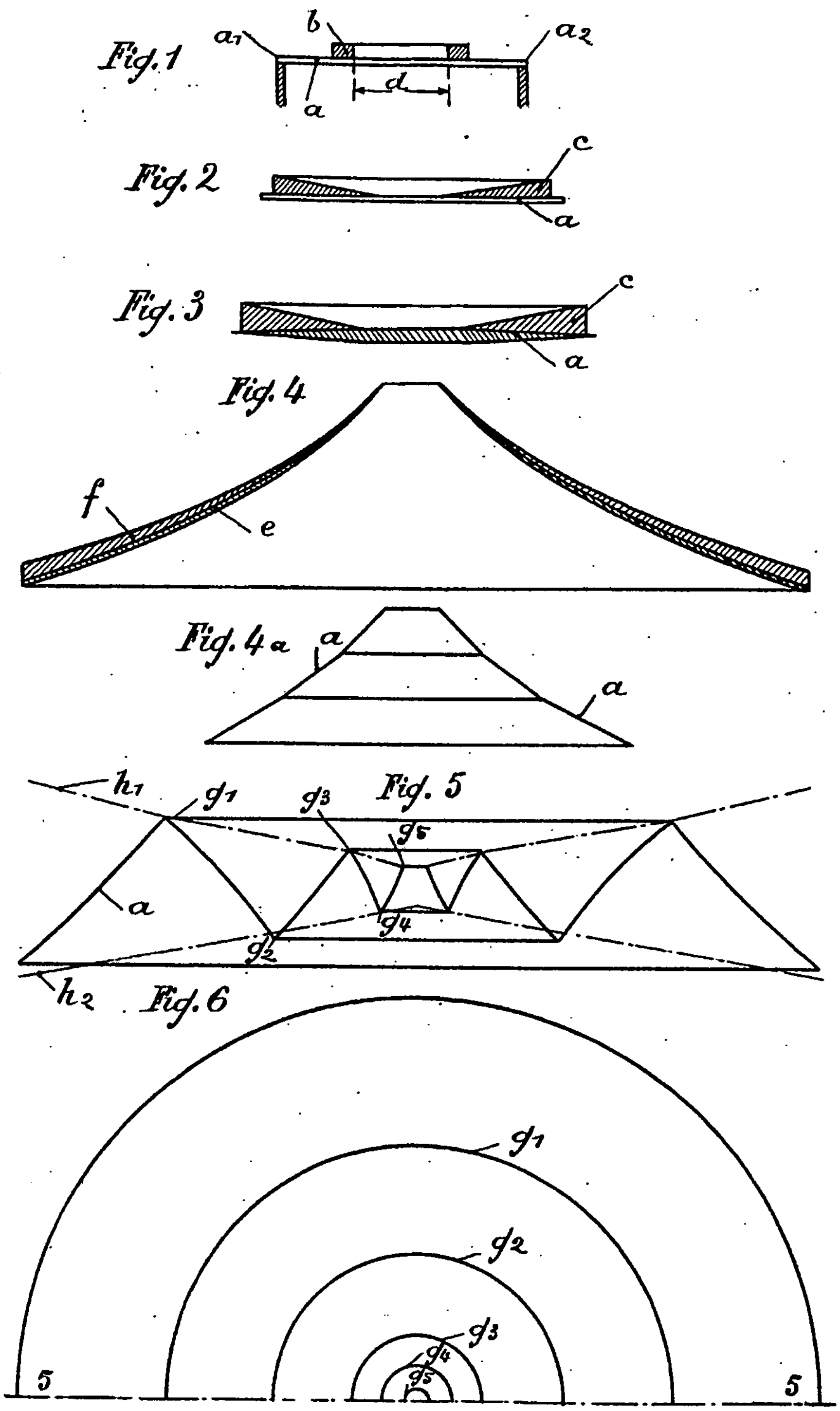


[This Drawing is a reproduction of the Original on a reduced scale]

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